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Grounded in data –
Informing **climate action**
and **reporting with national**
forest inventories

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Grounded in data - Informing **climate action** and **reporting with national** **forest inventories**

1. National forest inventory: overview

Despite the multitude of goods and services provided by forests, such as climate change mitigation, the world's forestlands are reduced day after day. Effective and transparent actions to reverse this trend and ensure the continued provision of forests' benefits depend on robust forestry data, as provided by national forest inventories (NFIs).

NFIs are defined in FAO's *Voluntary Guidelines on National Forest Monitoring* (FAO, 2017) as the technical process of data compilation and analysis of forest resources from a multitude of data sources to estimate relevant forest characteristics at points in time. Cyclical in nature, the NFI process can be improved over time through detailed reporting, which is key to capitalizing on the investment and ensuring that useful lessons can be drawn from its implementation. Because they are multipurpose, NFIs address a comprehensive evaluation of forests and their conditions, management and uses, covering all the thematic elements for sustainable forest management. NFIs are fundamental building blocks for national forest monitoring systems (NFMSs), which comprise the people, institutions and resources involved in national forest monitoring at the country level.

The primary goal of an NFI is to support sustainable forest management at national and subnational levels. NFIs thus contribute to the

maintenance and enhancement of the economic, social and environmental values of forests for the benefit of present and future generations. Specific NFI objectives include:



Assessing forest resources. NFIs aim to provide robust and up-to-date information on the extent, biodiversity, health and vitality, and productive and protective functions of forests. This includes information on carbon stocks and fluxes in forest ecosystems, essential for national inventories of anthropogenic emissions and removals of greenhouse gases (GHGs).



Informing decision- and policymakers. Transparent and scientifically sound forest information is essential to inform decision-makers and to support subnational- and national-level policies, such as climate change mitigation and adaptation planning. In the long term, institutionalized NFIs, with successive cycles, provide data not only for formulating but also for monitoring and adjusting public policies. At the international level, forest data from NFIs are useful for tracking countries' actions to address the climate and biodiversity global crisis.



Informing research and education. NFIs generate valuable data for scientific research, modelling, and education in forestry, ecology, biodiversity conservation, and related fields.



Promoting transparent accountability in forest management. NFIs provide data that can be used to assess the performance of government agencies, forest industries, and other stakeholders involved in forest management and conservation in the medium and long term.



Informing on the socioeconomic functions of forests. NFIs provide key information on the direct interactions between people and forests, including their relevance to the livelihoods of Indigenous Peoples and those of local communities.

A continuous and multipurpose NFI can be a vector for positive impacts on society because its capillarity enables forestry technicians to reach people living in and around forests. Data collection combined with information dissemination can be highly beneficial in raising awareness on forests. Cross-cutting themes can also be integrated into all phases of the NFI, such as identifying gender issues and including gender-responsive actions to help overcome historical gender biases in the forestry sector.

A blue-tinted photograph of a tree trunk on the left and a plant in the foreground. A dark, rectangular label is placed diagonally across the plant. The label has white text that reads "cassia nodosa" and "Pink cassia". The background is a blurred field of dry grass or straw.

cassia nodosa
Pink cassia

2. National forest inventory: data

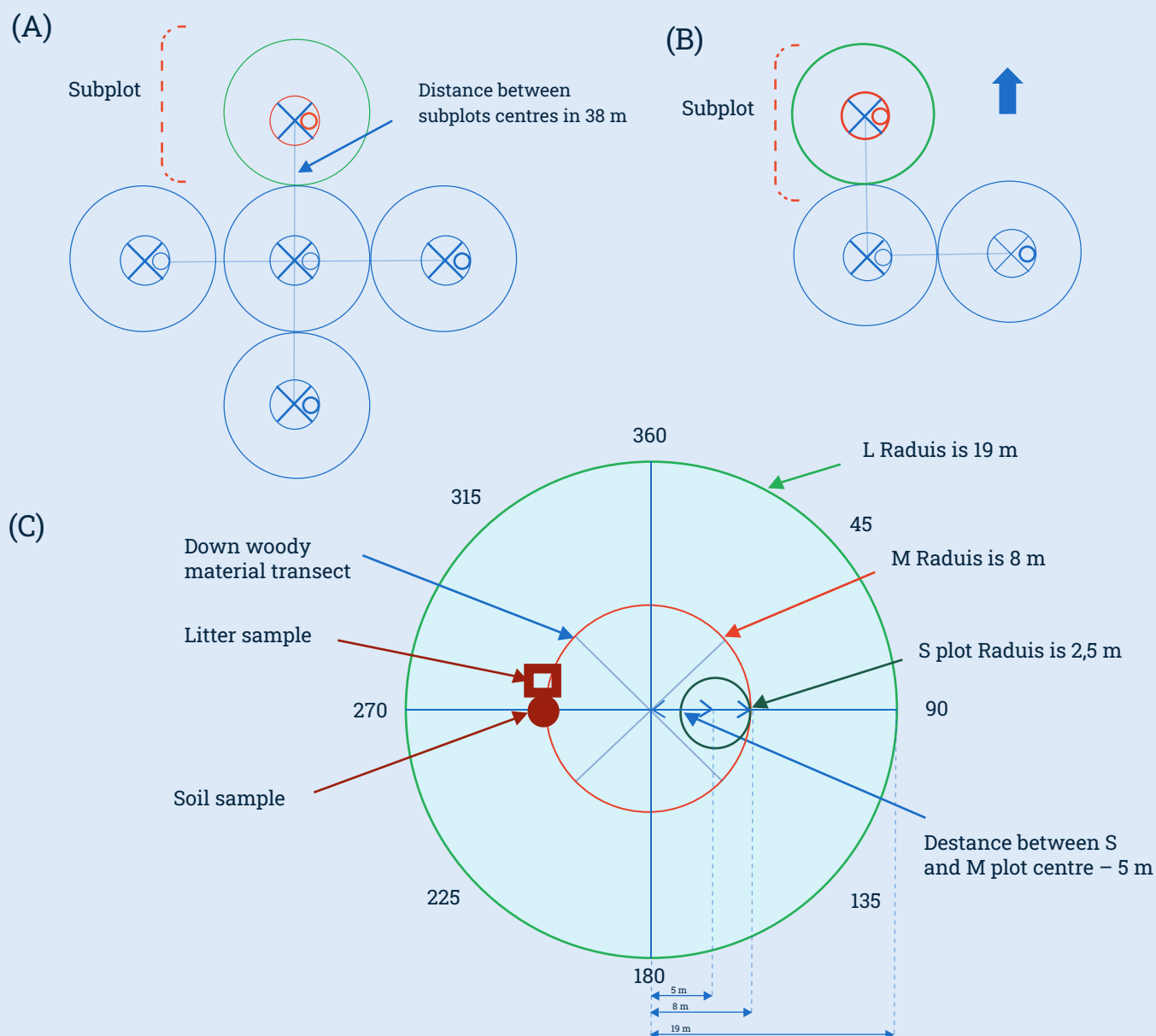


The outputs of an NFI are user oriented. In that sense, an assessment of stakeholders' information needs during the preparatory phase of an NFI is useful to clearly define the relevant data that should be acquired. Through scientifically sound methodologies, NFIs take advantage of a wide range of data sources, the two main ones being *in situ* and *ex situ* surveys:

- ▷ *In situ* forest data refers to **field data collection through ground data acquisition**. Field data collection is a staff-intensive endeavour that also requires significant logistical planning. The observations made on the basic sampling unit, the **inventory plot (Figure 1)**, taking advantage of technological improvements (e.g. laser distance measurement, high-precision GPS receivers, tablet recording synced with cloud-based database management systems), enable the complexity of nature to be captured into robust data and to turn it into valuable information and knowledge. *In situ* measurements are collected at the plot level (such as plot location, forest type, non-wood forest products, disturbance or degradation status, forest structure and terrain conditions), subplot level (such as regeneration, litter and dead wood assessment) and at the tree level (such as trunk diameter, canopy diameter, total height, and species identification). *In situ* data also refers to data collected in the surroundings of the plot, mainly related to the direct users of the forest resources.
- ▷ *Ex situ* forest data refers to **data collection through geospatial and remote sensing analysis** (sample based or wall to wall) that benefits from the increasing availability of data and processing platforms. These data may refer to forest area extent and forest area changes, including deforestation; stratification by forest types; and modelling and regionalization of target variables, such as above-ground biomass.

In terms of *in situ* and *ex situ* integration, remote sensing data analysis often relies on ground reference data coming from *in situ* observations. A valuable contribution of *in situ* observation in this context is the possibility of collecting information on land and forest use, which is one of the main challenges for remote sensing-based analyses (for instance, on agroforestry systems).

Figure 1 The forest inventory plot



Notes: The Bangladesh Forest Inventory plot. (A) Plot design for Hill, Sal, Coastal and Village zones- one plot is composed by five sub-plots, (B) Plot design of Sundarban zone- one plot is composed by three sub-plots. (C) Subplot layout for data collection.

Source: Government of Bangladesh. 2019. *Tree and forest resources of Bangladesh: Report on the Bangladesh Forest Inventory. Section 2: The Bangladesh Forest Inventory.* Forest Department, Ministry of Environment, Forest and Climate Change, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. http://bfis.bforest.gov.bd/bfi/wp-content/uploads/2020/08/BFI_report_final_section_02.pdf

Information provided by multipurpose NFIs can be organized as follows:



Biophysical and environmental data and information related to the forest on the extent of forest, forest biological diversity, health and vitality, provision of ecosystem services such as water and carbon storage, and protective and productive functions. This information can also relate to the landscape, including, for example, topography and transportation infrastructure.



Socioeconomic data and information related to the users on who is using the forest (including data according to gender, Indigenous Peoples status, and vulnerable groups), where, why and to what extent, who the key stakeholder groups are, and other related socioeconomic information



Governance and management information related to the way the forests are managed: in other words, the legal, policy and institutional framework



Information regarding the interactions at the landscape level related to the interactions of the forest and other land uses, including all the products and services from those different interactions. This dimension includes the three dimensions listed above at the landscape level.

In order to take appropriate climate actions and report on their efforts towards the successful implementation of the Paris Agreement, countries require transparent and robust forest data and information – precisely what NFIs can provide.

Box 1 Open Foris toolbox

FAO's [Open Foris initiative](#) is a collaborative effort providing a set of free and open-source tools designed to facilitate *in situ* and *ex situ* data collection, analysis, and reporting:

- ▶ Field data collection: Arena Mobile and Ground
- ▶ Field data management and analysis: Collect and Arena
- ▶ Reference *ex situ* data collection: Collect Earth and Collect Earth online
- ▶ Geospatial analysis: SEPAL and Earth Map

Open Foris solutions have transformed countries' ability to monitor and report positive actions on their forests over the last decade. Open Foris tools have been applied in national forest inventories in more than 25 countries, including Argentina, Bangladesh, Bhutan, Ecuador, Ethiopia, Mexico, Sri Lanka, Uganda, the United Republic of Tanzania, Viet Nam, and Zambia. In the REDD+ context, 73 percent of all 2014–2019 forest reference-level submissions to the United Nations Framework Convention on Climate Change used at least one Open Foris solution, this share increased to 92 percent for the 2020–2024 submissions (Sandker et al., 2024).

Sandker, M., Lindquist, E., Poultouchidou, A., Gill, G., Santos-Acuña, L., Neeff, T. & Fox, J. 2024. Technological innovation driving transparent forest monitoring and reporting for climate action. Rome, FAO. <https://doi.org/10.4060/cd0143en>



NFIs generate large volumes of data. In NFIs, databases are used to manage and archive field inventory data, field photographs, maps and remote sensing data, and related documents (such as field manuals, guidelines, and inventory reports). For creating databases, attention needs to be given to data integrity and how to maintain it while enabling users to access, manipulate, report, and represent data. In this regard, web portals and dashboards, eventually allowing online analytical processing to quickly execute complex analytical queries, are good instruments for improving the visibility, accessibility and transparency of NFI data and information.

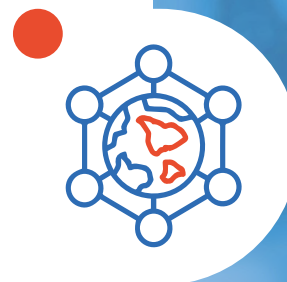
Beyond the data itself stored in an NFI, it is equally important that the NFI describe and record information about the data, the so-called metadata. Metadata is structured information that describes, explains and locates data, or otherwise makes it easier to retrieve, use or manage an information resource. An example of a catalogue providing forest inventory data is [Food and Agriculture Microdata Catalogue \(FAM\)](#).



Box 2 - Brazil national forest inventory data at FAO's FAM Catalogue

Brazil is a large country of 851 million hectares, of which about 57 percent is covered by forests, which constitutes the second largest forest area in the world (FAO, 2020). Given this magnitude, the implementation of a national forest inventory (NFI) is particularly challenging. The first forest inventories in Brazil were conducted in the mid-1950s in the Amazon region. The other parts of the country were covered in the 1980s, with over 250 million hectares inventoried. The NFI was reinstated in 2005, and, following a methodological review, data collection campaigns began in 2011. Even though this collection cycle is underway, the data already collected are found on the [IFN open data portal](#). All the data collected so far is available and can be updated almost simultaneously with the progress of data collection in the field. The Brazilian NFI database is available on FAO's FAM.

An important instrument in the dissemination of NFI results is the publication of the methodology and data in the form of scientific papers or technical reports. Data transparency not only provides an opportunity for greater use of data but also promotes debates, exchanges and collaboration. In that direction, regional NFI **networks**, comprising multicountry working teams, have emerged as a solution to produce comparable and harmonized forest information at the landscape scale. By connecting countries, experts and organizations, these networks can facilitate training programmes and technical exchanges, fostering the capacity development of a skilled workforce and facilitating the transfer of expertise across countries and regions, improving the overall quality and transparency of NFIs. This was the case in Latin America and the Caribbean, where a network of NFI experts worked together on a reference book that compiles the NFIs of 21 countries towards the harmonization of forest information in the region (Ramírez *et al.*, 2022).



Box 3: National Forest Inventory networks around the world

To date, there are three networks of forest inventories linking countries at the regional level:

- ▶ **The European National Forest Inventory Network** was created in 2003 with the objective of promoting national forest inventories as comprehensive monitoring systems. **31 countries** are currently engaged in collecting harmonized information on forest ecosystems and landscape changes.
- ▶ **The North American Forest Commission** was established in 1958 as one of six regional forestry commissions of FAO. Its Inventory and Monitoring Working Group provides a policy and technical forum for Canada, Mexico and the United States to discuss and address forest issues throughout North America.
- ▶ **The Latin American and the Caribbean Forest Inventory Network's** first national forest inventory expert meetings started in 2012 and were consolidated in 2018. This initiative brings together 21 countries and five territories.

For the **Asian network**, initial steps are being made in 2024 to collect information on the status of national forest inventories in the region. These initiatives have proven to be effective mechanisms to enhance cooperation among participants, providing visible platforms for the exchange of harmonized forest data and fostering an enriching and synergistic exchange among national forest inventory organizations. Furthermore, the networks are contributing to FAO's [Global Forests Resources Assessment](#) process, ensuring their impact beyond the regions.

FAO, through the "[Building global capacity to increase transparency in the forest sector \(CBIT-Forest\)](#)" global project, funded by the Global Environment Facility, will continue to support the Latin American and Caribbean forest inventory network and facilitate the establishment of such for Asia. This project aims to enhance the quality, timeliness, accessibility and usability of forest-related data in line with the enhanced transparency framework requirements of the Paris Agreement.

3. National forest inventory: international reporting

The need for data on forests permeates a great variety of initiatives, conventions and agreements in the international sphere (Box 6). In the context of the United Nations Framework Convention on Climate Change (the Convention), transparency includes the reporting and review of relevant climate information and data, which include the forest sector data. Transparency arrangements under the Convention enable the availability of regular data on countries' GHG emissions, policies and measures; progress towards targets; climate change impacts and adaptation; levels of support; and capacity-building needs. By providing clear and robust data and information on climate action, transparency also serves to build trust, credibility and accountability among all those involved.

With the adoption of the Paris Agreement, Parties have presented their nationally determined contributions (NDCs) aiming to collectively limit the global average temperature increase. To ensure transparent reporting of these mitigation actions, the [enhanced transparency framework \(ETF\)](#), introduced in Article 13 of the Paris Agreement, builds on the Convention's existing measurement, reporting and verification (MRV) existing arrangements.

The information gathered through the biennial transparency report (BTR) will feed into the global stocktake, which will assess the collective progress towards the long-term climate goals. **Transparency reports to the Convention are as follows:**



National GHG inventory report: A report to be presented annually by developed countries Parties and by all Parties as part of the BTR and national communication. National GHG inventories provide emissions and removals estimates for different sectors: energy; industrial processes and product use; agriculture; land use, land-use change and forestry; and waste, following methodological guidelines from the Intergovernmental Panel on Climate Change (IPCC). The overall approach states that activity data and emission factors are the basis for GHG flux estimates. Within the forestry subsector, activity data mainly relate to forest area extent and its changes, which are collected through NFMS, possibly upon NFI data. NFIs are particularly important sources of country-specific emission factors, which depend on carbon stocks within the different carbon pools stated by the IPCC (biomass, dead organic matter, soils and harvested wood products) and are estimated upon primary *in situ* and *ex situ* data (e.g. dendrometry [tree measurements], biomass maps, tree mortality, soil carbon stocks, root-to-shoot ratios, dead wood volume and litter stocks).



National communication: Information to be presented every four years by all Parties, including national circumstances – to which NFIs can provide information on the forestry sector – and institutional arrangements descriptions, a national GHG inventory, as described above, and a general description of steps taken or envisaged to implement the Convention.



Biennial transparency report (BTR): The report is meant to present updates to the national communication regarding national GHG inventories and information on adaptation and mitigation actions, as well as needs and support received or provided. An example on the use the NFI for reporting is provided in Box 4 For the Parties to the Paris Agreement, the BTR replaces the biennial report or biennial update report. **The BTR structure includes:**

A national GHG inventory report for which NFIs typically provide activity data and emission factors, as detailed above.

- ▶ **Information necessary to track progress in implementing and achieving NDCs.** Forest-based mitigation actions include conserving and enhancing carbon stocks and reducing emissions from deforestation and forest degradation (REDD+). Aligned to this, 95 percent of updated NDCs include mitigation in the agricultural and/or land use, land-use change and forestry (FAO, 2022).

Information on climate change impacts and adaptation. NFIs can provide reliable information on climate-related impacts on forests and people to help guide forest-

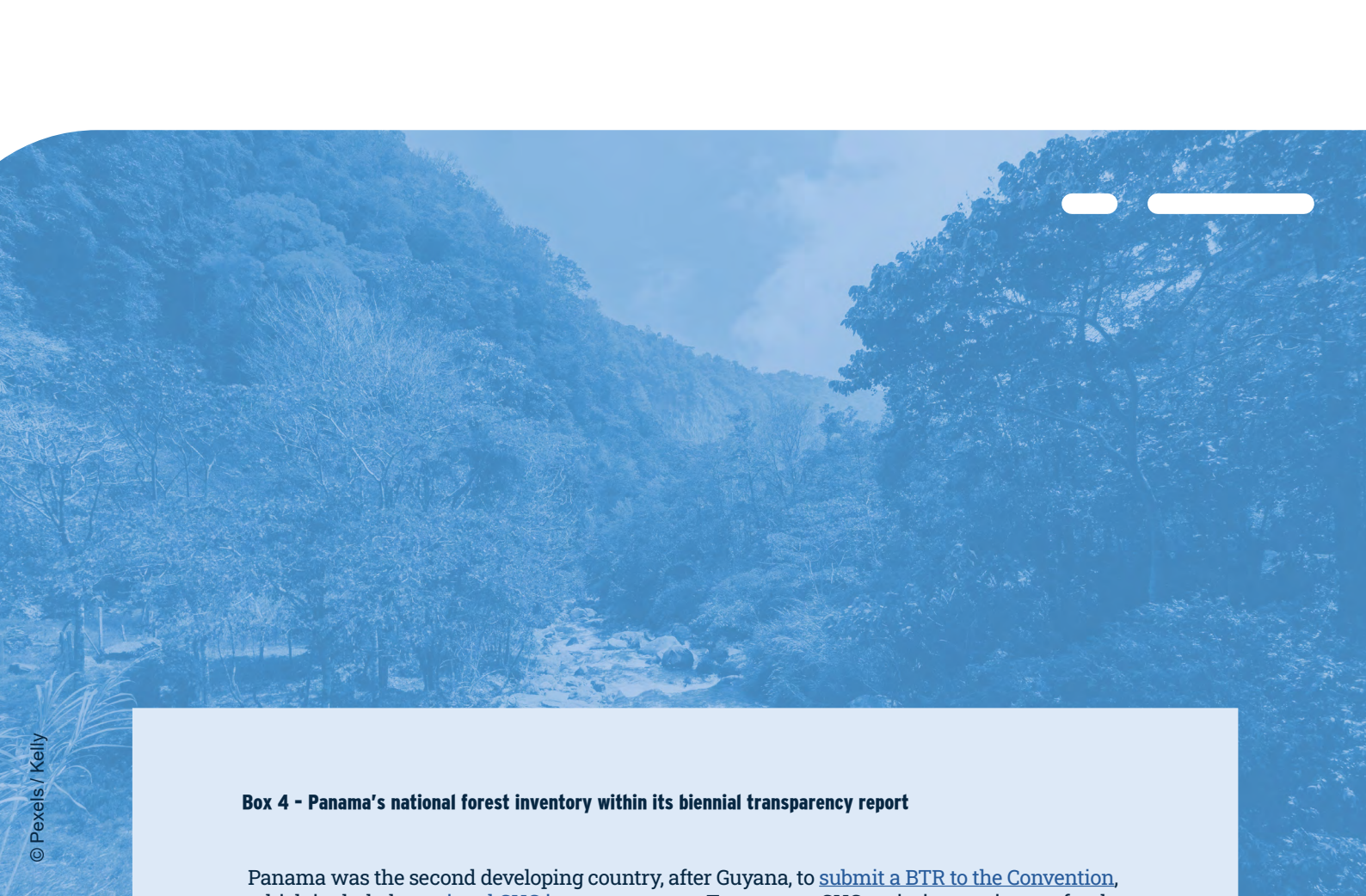
- ▶ based adaptation measures. NFIs can gather information on forest disturbance events (frequency and impacts) due to climate change, such as prolonged droughts and other extreme climate events, as well as long-term changes to forest structure and composition. Multipurpose NFIs can provide insights are on the consequences of climate change on the livelihoods of Indigenous Peoples and local communities and their resilience and adaptive capacity. In terms of forest-based adaptation measures, NFI data may inform adaptive management of forestry resources, such as the need to change cycles of timber harvesting and non-timber forest product collection, conservation and restoration efforts for water provision, or integrated fire management approaches.

Information on financial, technology transfer and capacity-building support provided or received. Multipurpose NFIs can deliver data to inform on support actions to the forestry sector;

- ▶ for example, a country may receive support to implement reduced impact logging techniques, thus reducing logging damage and consequently reducing carbon stock changes and associated emissions. NFIs can capture significant forest management improvements at the national level.

REDD+ results. REDD+ reporting continues under

- ▶ Article 5 of the Paris Agreement. REDD+ results, measured against reference levels, are presented voluntarily as an annex to the BTR and also depend on activity data and emission factors that may be delivered through NFIs. Throughout the years, NFIs can fulfil national data needs and provide, for instance, new or updated emission factors, allowing for more accurate, consistent and complete emissions and removals estimates.



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Box 4 - Panama's national forest inventory within its biennial transparency report

Panama was the second developing country, after Guyana, to [submit a BTR to the Convention](#), which included a [national GHG inventory report](#). To generate GHG emissions estimates for the Land Use, Land-Use Change, and Forestry (LULUCF) sector, Panama utilized the Collect Earth Desktop tool, an Open Foris solution, to produce activity data. Within the same sector, Panama leveraged data from its National Forest and Carbon Inventory (Inventario Nacional Forestal y de Carbono de Panamá - INFC) on biomass and dead organic matter carbon pools to establish national emission factors, which were then combined with IPCC default emission factors. The use of statistically robust data allowed the sector's results to be presented with associated uncertainties, underscoring the country's commitment to high environmental integrity in forest-related emissions measurements.

In the BTR chapter dedicated to information on financial, technology transfer, and capacity-building support provided or received, Panama highlights the need to develop the first Peatland Map of Panama, including the determination of carbon stocks. This effort is based on the strengthening of the forest and carbon inventory, where the sampling units for peatlands will be expanded. Among its updated Nationally Determined Contributions (NDCs), referenced in Chapter 2 of the BTR, Panama includes three forest-specific measures. Target 2.2 involves the development and implementation of the [National REDD+ Strategy](#), which emphasizes the role of its NFI, as part of the NFMS, in providing data that is converted into national-specific emission factors for deforestation and degradation activities across different forest types.

Panama's first BTR also includes a REDD+ technical annex that presents the results achieved in implementing the five activities from 2018 to 2022. The reductions amount to -11.9 Mt CO₂eq, benchmarked against Panama's [forest reference level](#) of -20 Mt CO₂eq/year, which corresponds to the 10-year historical average from 2005 to 2015. In this annex, Panama underscores that its multi-purpose NFI provides volumetric and carbon stock data, as well as information that supports the evaluation of public policies in the forestry sector. While Panama's first reference level used partial NFI data to derive emission factors, the second reference level benefited from the completion of the first NFI cycle in 2018. The design of the NFI includes 87 permanent sampling units where in situ data—such as tree measurements, litter, dead wood, soils, land use, forest degradation status, various environmental variables, and socio-economic information—will be collected every five years.

REDD+ results are eligible for payments under the Convention and the Paris Agreement once all requirements set out in the Warsaw Framework have been met. An example of the use of the NFI for REDD+ reporting is available in Box 5. These requirements, or elements, relate to NFIs in different ways:



National REDD+ Strategy or action plan:

Multipurpose NFIs provide essential information on the drivers of deforestation and forest degradation, land tenure issues, forest governance issues, gender considerations, and stakeholder identification and engagement, including for Indigenous Peoples and local communities.



A safeguards information system allowing the periodic provision of the safeguards information summary: Well-implemented and institutionalized multipurpose NFIs can be a primary instrument for monitoring safeguard information system criteria and indicators. For instance, NFIs provide data on non-wood forest products, including food, fodder and fibre, which are essential for sustainable livelihoods for Indigenous Peoples and local communities.



NFMS: NFIs are an essential part of NFMS along with land satellite monitoring systems, providing activity data and emission factors to GHG emissions and removals estimates. In addition, NFIs provide important ground-based observations to the integration with land satellite monitoring systems, such as data on forest types for stratification and reference data on area change and biomass.



Forest reference emission level or forest reference level, expressed as tonnes of CO₂ equivalent per year for a reference period: This level should be established in accordance with IPCC guidelines to GHG inventories to which NFIs can provide primary sources of activity data and emission factors. Of the 63 reporting countries, 53 (84 percent) have an NFI or are in the process of collecting their NFI data. Though sometimes complemented with IPCC default values, NFI data are the most frequent data source for emission factors (Sandker *et al.*, 2024). The ten countries (16 percent) that do not have an NFI all use inventory data from local inventories or from neighbouring countries.



Box 5 - How Mexico used national forest inventory data in measurement, reporting and verification for REDD+

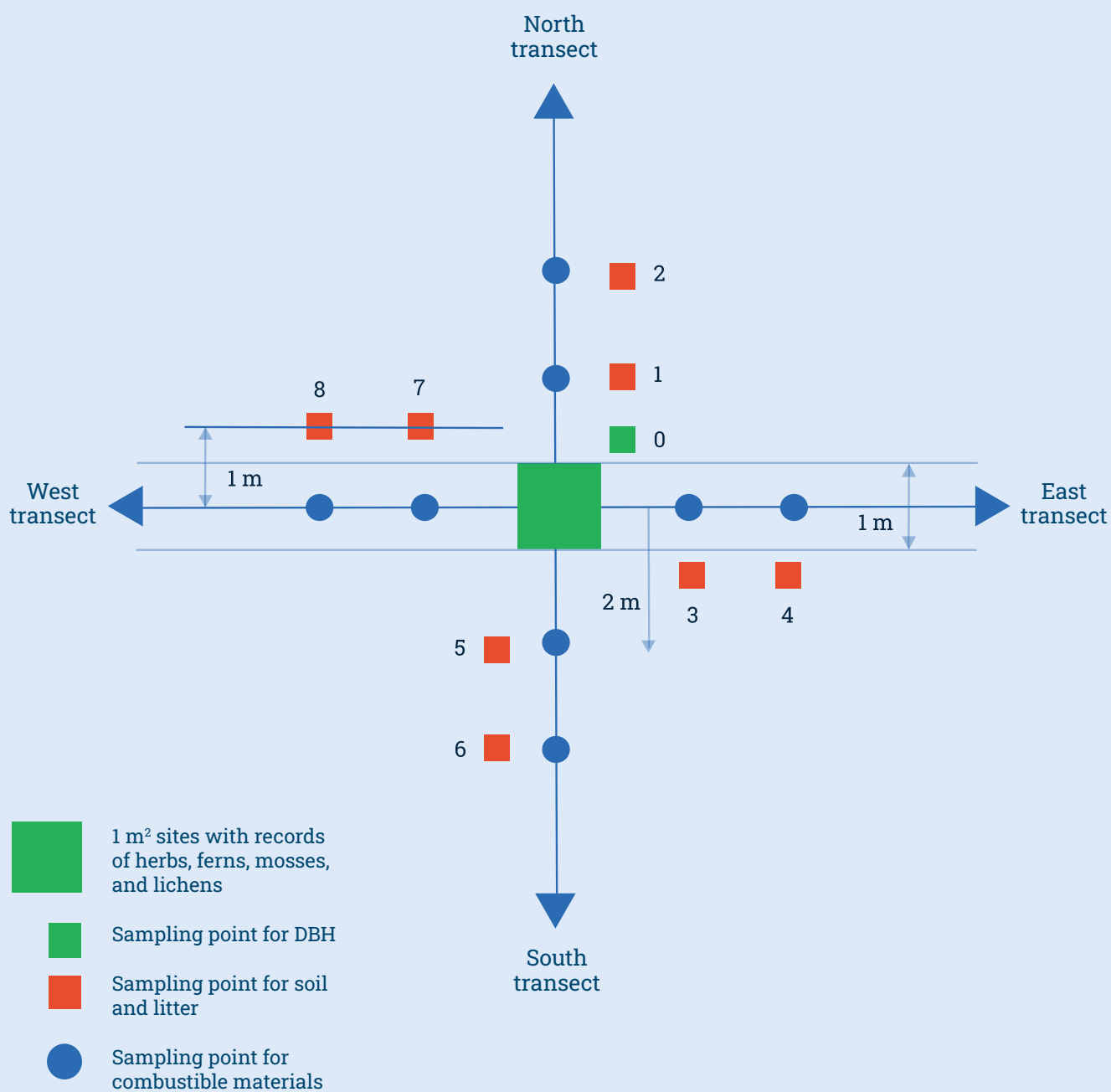
The National Forest and Soils Inventory (Inventario Nacional Forestal y de Suelos – INFyS) is a pillar of Mexico's National Forest Monitoring System, carried out and published by [CONAFOR](#). The country has completed three cycles of the INFyS data collection, which is reflected in the progressive and improved contribution to the measurement, reporting and verification processes for reducing emissions from deforestation and forest degradation (REDD+).

The first INFyS cycle was conducted between 2004 and 2007 and provided floristic and dendrometric data used to estimate above-ground and below-ground carbon stocks upon the application of a great variety of allometric equations and expansion root-to-shoot factors. Carbon stocks were then used to generate national specific emission factors used in Mexico's [first forest reference emission level](#) submitted to the United Nations Framework Convention on Climate Change in 2014 for the reference period 2000–2010 (44 Mt CO₂ eq/yr).

The completion of two INFyS cycles benefited Mexico's [forest reference emission level update](#) submitted in 2020 (for the reference period 2007–2016 and was estimated at 20 Mt CO₂ eq/yr), by providing more complete and accurate information. The INFyS data were used to stratify forestlands into more homogeneous areas to which specific carbon stocks were associated, for each carbon pool (above-ground and below-ground biomass, dead wood, litter and soil organic carbon) also estimated upon INFyS information (tree species, above-ground biomass, dead wood, litter and woody carbon fractions – Figure 2).

Finally, as an annex to its biennial update report, Mexico reported [results](#) from the implementation of reduced emissions from deforestation and forest degradation activities, estimated against the updated forest reference emission level, which amount to emission reductions of 6 Mt CO₂ eq/yr, and a total of 18 Mt CO₂ eq for the period 2017–2019. Those results benefited from a third cycle of INFyS data collection, enabling improvements in carbon stock estimates of the different pools, including dead wood and litter, which are more complex reservoirs very often not excluded from NFI data collection.

Figure 2: General scheme of subsampling unit used in Mexico's INFyS for data collection on fallen woody material, soil and litter



Source: Government of Mexico. 2021. *Nivel de referencia de emisiones forestales de México (2007-2016) Modificado*. México City, Government of Mexico, p. 142. redd.unfccc.int/media/nref_2020_modificado_mexico_23072021_nt_20220103_clean.pdf

Box 6 Other national forest inventory data-consuming reports and initiatives

Under the Convention on Biological Diversity, country Parties to the [Kunming-Montreal Global Biodiversity Framework](#) have committed to achieve 23 global [targets](#) for urgent action by 2030; for instance, target 2 is to restore 30 percent of all degraded ecosystems. Transparency instruments of these agreements include the National Biodiversity Strategies and Action Plans and National Reports for which national forest inventories are unquestionable sources of data and information.

Other international initiatives consuming national forest inventory data are the following:

- ▷ [Global Forest Resources Assessment](#), from FAO
- ▷ [Sustainable Development Goals](#)
- ▷ United Nations Decade on Ecosystem Restoration 2021–2030
- ▷ [International Tropical Timber Organization](#) criteria and indicators,
- ▷ [Convention on International Trade in Endangered Species of Wild Fauna and Flora](#)
- ▷ [Bonn Challenge](#)
- ▷ Latin American and Caribbean [Initiative 20×20](#) on restoration of deforested and degraded landscapes





Conclusion

As countries strive to meet international reporting requirements while strengthening their NFMSs, the importance of national forest inventories cannot be underestimated. These systematic processes of collecting, analyzing, and reporting forest data play a pivotal role in providing estimates on key variables related to the characteristics of forests across an entire country, including emission factors for calculating forest-related greenhouse gas emissions and removals.

Beyond their carbon-focused function, NFIs offer vital insights into forest biodiversity, health, management, and use, empowering countries to make informed decisions on national policy and forest management. Recognizing the complexity of NFIs, regional national forest inventory networks have emerged as valuable spaces for knowledge sharing, promoting the production of comparable and harmonized forest information at the landscape scale.

To enhance capacities in this field, FAO has renewed its [NFI e-learning series](#), which includes eight courses, each focusing on different phases of the NFI process. Combined with the [forest monitoring for climate action e-learning series](#) – designed to strengthen institutional and technical capacities for meeting the measurement, reporting, and verification (MRV) requirements under the UNFCCC – both practitioners and students can benefit from FAO's significant efforts to highlight the role of forests and forest data in climate reporting. For more information on FAO's Forest Monitoring and Data Platforms work, visit our [website](#).



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